ORIGINAL ARTICLE

Effects of Author Contribution Disclosures and Numeric Limitations on Authorship Trends

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OBJECTIVE: **To determine whether editorial policies designed to eliminate gratuitous authorship (globally referred to as *authorship limitation policies*), including author contribution disclosures and/or numeric restrictions, have significantly affected authorship trends during a 20-year period.**

METHODS: **We used a custom PERL-based algorithm to extract data, including number of authors, publication date, and article subtype, from articles published from January 1, 1986, through December 31, 2006, in 16 medical journals (8 with explicit authorship guidelines restricting authorship and 8 without formal authorship policies), comprising 307,190 articles. Trends in the mean number of authors per article, sorted by journal type, article subtype, and presence of authorship limitations, were determined using Sen's slope analysis and compared using analysis of variance and matched-pair analysis. Trend data were compared among the journals that had implemented 1 or both of these formal restrictive authorship policies and those that had not in order to determine their effect on authorship over time.**

RESULTS: **The number of authors per article has been increasing among all journals at a mean ± SD rate of 0.076±0.057 authors per article per year. No significant differences in authorship rate were observed between journals with and without authorship limits before enforcement (*F*=1.097; *P*=.30). After enforcement, no significant change in authorship rates was observed (matched pair: *F*=0.425; *P*=.79).**

CONCLUSION: **Implementation of authorship limitation policies does not slow the trend of increasing numbers of authors per article over time.**

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Authorship of peer-reviewed publications is one of the primary metrics of success in the academic environment. In the current competitive academic climate, there is enormous pressure to publish with sufficient frequency to retain academic relevance, ensure continued funding, and meet institutional expectations.[1,2] Unfortunately, the increasing demands made on academicians in science and medicine have diverted more and more time away from the process of publication and scientific research. These pressures are cited as causative factors in the misattribution of article authorship to undeserving and excessive coauthors.[1-5] Indeed, data suggest that coauthorship has increased during the past 20 years, yet the reasons behind this increase remain controversial.[3-7]

Since 1978, the group currently known as the International Committee of Medical Journal Editors (ICMJE) has met to enact uniform requirements for manuscripts submitted to biomedical journals. Although the initial intent of the ICMJE was to consolidate publication format, its scope has broadened throughout the years to include ethical issues surrounding authorship standards. In 1997, and later again in 2004, the ICMJE code was substantially rewritten to address concerns surrounding undeserving authorship by increasing the stringency of authorship guidelines. In response, many medical journals and editors have adopted these guidelines to ensure proper attribution of authorship through enforcement of various authorship limitation policies, including disclosure forms, published disclosure statements, and, in some cases, limits to the number of authors per article.[8-13] Notwithstanding widespread adoption of these authorship policies, few large-scale studies have been conducted on the effect of these policies on patterns of authorship.[3,4,6,9,14-16] In an effort to determine whether authorship policies affect the total number of authors per article, we compared rates of change over time in the mean numbers of authors per article between journals that have and have not implemented 1 or more of these policies.

METHODS

JOURNAL SELECTION, ARTICLE CATEGORIZATION, AND IDENTIFICATION OF AUTHORSHIP REGULATION

Sixteen well-known medical journals were selected for study on the basis of journal subtype (general medical journal vs specialty medical journal) and the presence or absence of ICMJE-derived authorship limitation policies. On the basis of MEDLINE classification criteria,[17] articles from each journal were subtyped as original research, randomized controlled trials, multicenter trials, or review articles. Dates of enforcement of authorship policies were identified using a combination of PubMed, a comprehensive search of the historical instructions to authors in print and online, and direct contact with the journal editorial office.

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PubMed Data Collection

Using the Entrez Programming Utilities,[17] we generated a PERL script (see Supporting Online Material; eDocument) to extract information from the PubMed database on all articles published from 16 well-known journals during a 20-year publication window (January 1, 1986, through December 31, 2006). Comma-delimited text output from this program included journal name, PubMed identifier code, number of authors per article, article subtype, and date (year, month) of publication. From these data, the total numbers of published articles and the mean numbers of authors for each journal and article subtype were computed.

Statistical Analyses

All statistical analyses were performed using JMP statistical software, version 8.0 (SAS Institute, Cary, NC), and Excel 2008 software (Microsoft, Redmond, WA). Authorship rate (eg, trend for the mean number of authors per article over time) was detected using Sen's slope method (Q score) for magnitude estimation.[18,19] In cases of journals with authorship limitation policies, trend analysis was performed separately during time ranges with and without enforcement of these policies. Significant differences between Q scores and nominal variables (eg, journal name, journal classification, article classification, presence of authorship limitation policies) were detected using 1-way analysis of variance followed by Tukey-Kramer Honestly Significant Difference analysis. Matched-pair analysis of Q scores was performed among journals with authorship limitation policies to determine the effects of enforcement on authorship rates.

RESULTS

Using the data collection and analysis strategy described in the Methods section, we identified and analyzed yearly authorship trends for 16 medical journals (Table 1). In total, 307,190 journal articles were included, representing all indexed articles published from these 16 journals during a 20-year interval (1986-2006). Article and journal distributions are represented in Figure 1 and Figure 2 and are quantified in the eTable.

Analysis of authorship during the 20-year period using Sen's slope estimates revealed a significant trend toward increasing authorship for nearly all journals and article subcategories (Tables 2-4). Before the enforcement of authorship limitation policies, multicenter trials had a significantly higher authorship rate (change in the number of authors per article over time as assessed by Sen's slope [Q]) compared with other article subcategories (F=3.979, P=.005; Tukey-Kramer Honestly Significant Difference test: P≤.03). After implementation of authorship limitation

TABLE 1. **Journal Statistics**[a]

Journal name	Reference	Journal subtype	Authorship limitation policies[b]: Contribution disclosure	Authorship limitation policies[b]: Numeric restrictions
AIM[c]	20-23	General interest	Yes (1998-current)	Yes (1995-2000)
BMJ[d]	24	General interest	Yes (1997-current)	No
JAMA[e]	14	General interest	Yes (2000-current)	Yes (1985-1997)
The Lancet	25	General interest	Yes (1997-current)	No
NEJM[f]	26,27	General interest	No	Yes (1992-2002)
AGP	28-30	Specialty, psychiatry	Yes (2002-current)	Yes (1994-2001)
AJR	31	Specialty, radiology	Yes (2005-current)	No
Radiology	32	Specialty, radiology	Yes (1997-current)	No
AJNR		Specialty, radiology	No	No
Blood	33-35	Specialty, hematology	No (2006-current)	No (2006-current)
Circulation[g]	36, 37	Specialty, cardiology	No	No
JACI		Specialty, allergy	No	No
JNCI		Specialty, oncology	No	No
JCI		General interest	No	No
Hepatology		Specialty, GI/liver	No	No
NM		General interest	No	No

[a] *AGP = Archives of General Psychiatry*; *AIM = Annals of Internal Medicine*; *AJNR = American Journal of Neuroradiology*; *AJR = American Journal of Roentgenology*; *BMJ = British Medical Journal*; GI = gastrointestinal; *JACI = Journal of Allergy and Clinical Immunology*; *JAMA = Journal of the American Medical Association*; *JCI = The Journal of Clinical Investigation*; *JNCI = Journal of the National Cancer Institute*; *NEJM = New England Journal of Medicine*; *NM = Nature Medicine*.

[b] Dates of enforcement of authorship limitation policies (formal contribution disclosures and/or restrictions on the number of authors) are listed along with any additional notes regarding enforcement or specifics of the criteria.

[c] Authorship restricted to 10 authors (3 for letters) in 1995. In 1997, numeric restrictions increased to 25. Unofficial contribution disclosures began in 1997, whereas official contribution disclosures were enforced starting in 1998.

[d] Unofficial contribution disclosures began in 1997 and were mandatory starting July 1, 2004. Journal hand searching revealed that most publications provided contribution disclosures before 2004.

[e] Between 1985 and 1997, the journal required justification if the maximum number of authors exceeded 6.

[f] Authorship limits varied with date: 1992-1995, had to give cause for >8 authors for a single study and >12 authors for a multicenter trial; 1996-2002, the number of authors was limited to 12.

[g] Formal authorship disclosure required in 2008. Beginning April 1, 2000, the number of authors on a letter was restricted to 3.

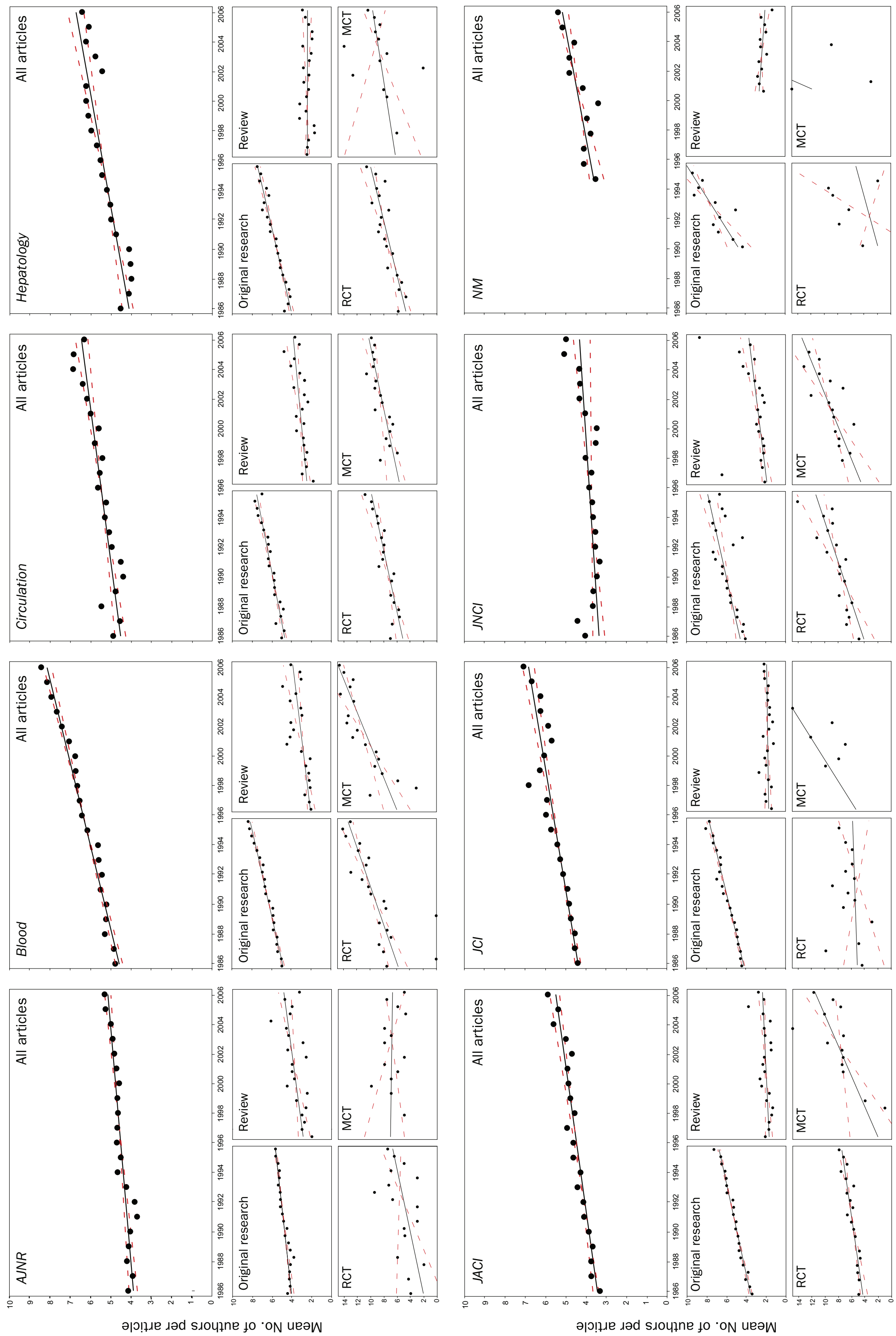

FIGURE 1. Authorship trends during a 20-year period among journals without authorship limitation policies. Mean authorship rates from 1986 to 2006 are shown for 8 journals without current or previous enforcement of authorship limitation policies. The mean number of authors per article (circles) is shown for all articles (large graph), as well as for article subtypes (smaller graphs). Sen's slope (solid line) with 95% confidence intervals (dashed line) are shown. *AJNR* = *American Journal of Neuroradiology*; *JACI* = *Journal of Allergy and Clinical Immunology*; *JCI* = *The Journal of Clinical Investigation*; *JNCI* = *Journal of the National Cancer Institute*; MCT = multicenter trial; *NM* = *Nature Medicine*; RCT = randomized controlled trial.

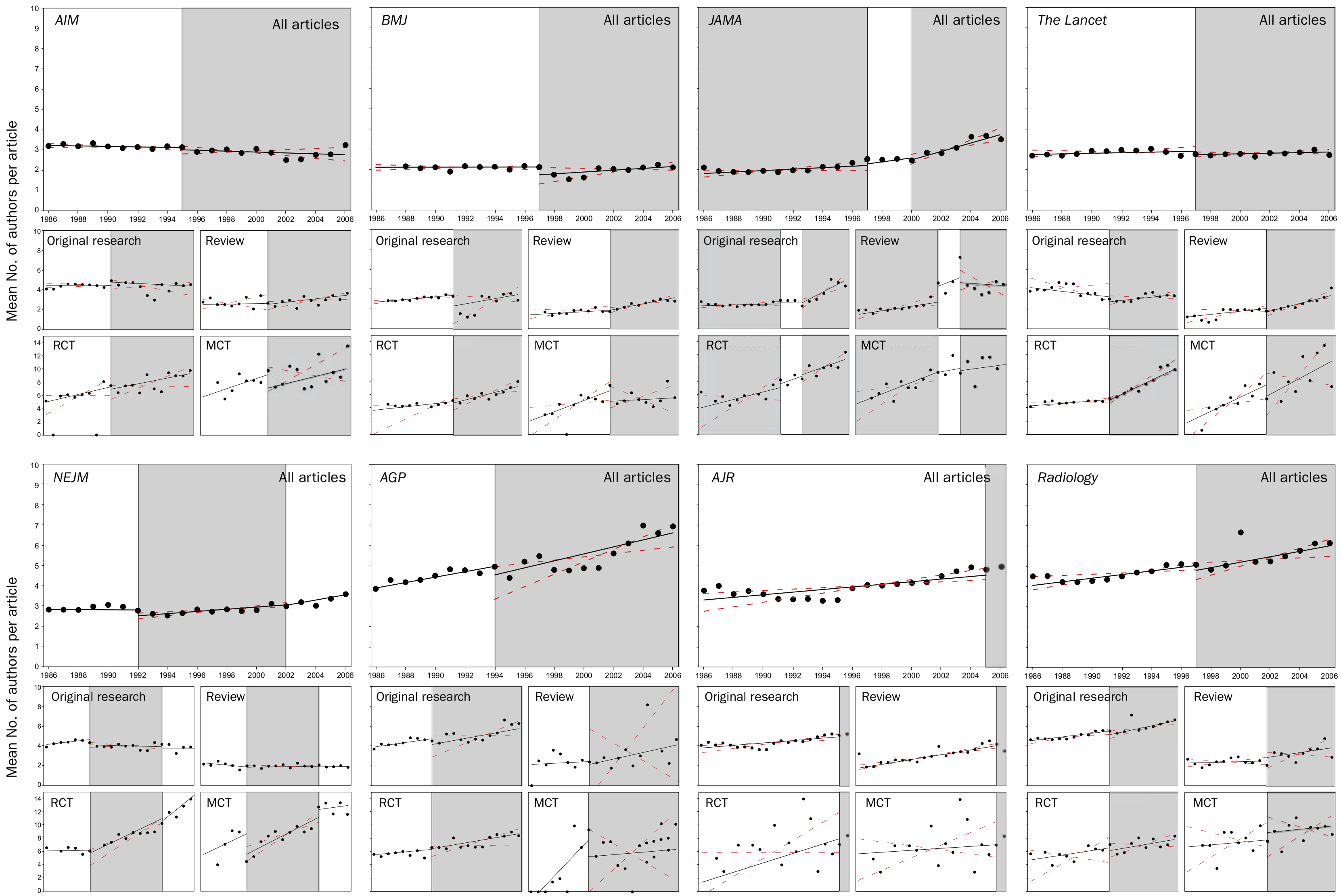

FIGURE 2. Authorship trends during a 20-year period among journals with authorship limitation policies. Mean authorship rates from 1986 to 2006 are shown for 8 journals with current or previous enforcement of authorship limitation policies. The mean number of authors per article (circles) is shown for all articles (large graph), as well as for article subtypes (smaller graphs). Sen's slope (solid line) with 95% confidence intervals (dashed line) are shown for both periods with (shaded regions) and without (unshaded regions) enforcement of either numeric limitations or disclosure statements. *AGP* = *Archives of General Psychiatry*; *AIM* = *Annals of Internal Medicine*; *AJR* = *American Journal of Roentgenology*; *JAMA* = *Journal of the American Medical Association*; MCT = multicenter trial; *NEJM* = *The New England Journal of Medicine*; RCT = randomized controlled trial.

TABLE 2. **Authorship Trends From 1986 to 2006 Among Journals Without Authorship Limitation Policies**

Journal	All published articles		Original research		Reviews		Randomized controlled trials		Multicenter trials	
	Q (95% CI)	*P* value	Q (95% CI)	*P* value	Q (95% CI)	*P* value	Q (95% CI)	*P* value	Q (95% CI)	*P* value
AJNR	0.062 (0.047-0.082)	<.001	0.081 (0.070 to 0.099)	<.001	0.099 (0.037 to 0.161)	<.01	0.233 (0.062 to 0.459)	<.01	−0.014 (−0.303 to 0.143)	NS
Blood	0.177 (0.152-0.202)	<.001	0.167 (0.145 to 0.189)	<.001	0.088 (0.025 to 0.170)	<.01	0.379 (0.239 to 0.615)	<.001	0.447 (0.241 to 0.775)	<.001
Circulation	0.112 (0.076-0.149)	<.001	0.142 (0.104 to 0.173)	<.001	0.074 (0.016 to 0.137)	<.01	0.249 (0.147 to 0.376)	<.001	0.198 (0.064 to 0.309)	<.001
JACI	0.101 (0.086-0.120)	<.001	0.159 (0.143 to 0.174)	<.001	0.034 (0.003 to 0.071)	<.05	0.159 (0.118 to 0.219)	<.001	0.476 (0.113 to 0.738)	<.01
JCI	0.122 (0.100-0.145)	<.001	0.175 (0.160 to 0.193)	<.001	0.011 (−0.020 to 0.039)	NS	0.037 (−0.192 to 0.346)	NS	0.688 (−1.090 to 3.482)	NS
JNCI	0.049 (0.008-0.077)	<.05	0.165 (0.099 to 0.230)	<.001	0.091 (0.046 to 0.158)	<.01	0.366 (0.223 to 0.586)	<.001	0.449 (0.272 to 0.724)	<.001
Hepatology	0.130 (0.096-0.162)	<.001	0.170 (0.145 to 0.196)	<.001	0.000 (−0.032 to 0.035)	NS	0.270 (0.181 to 0.383)	<.001	0.173 (−0.307 to 0.435)	NS
NM	0.140 (0.096-0.211)	<.01	0.473 (0.309 to 0.705)	<.01	−0.052 (−0.134 to 0.030)	NS	0.310 (−0.356 to 1.751)	NS	2.518 (−0.013 to 3.220)	NS

Sen's slope coefficient (Q, authors per article per year) with 95% confidence intervals (CIs) and statistical significance of slope calculations (*P* value) are shown for each journal and article subtype. *AJNR = American Journal of Neuroradiology*; *JACI = Journal of Allergy and Clinical Immunology*; *JCI = The Journal of Clinical Investigation*; *JNCI = Journal of the National Cancer Institute*; *NM = Nature Medicine*; NS = nonsignificant.

policies, multicenter trials and randomized controlled trials had significantly higher authorship rates when compared with other article subcategories (F=5.48, P=.001; Tukey-Kramer Honestly Significant Difference test: P≤.04).

Analysis of publication patterns failed to show a significant correlation between authorship rate and journal classification (before authorship limitation policy enforcement: F=1.486, P=.23; during authorship limitation policy enforcement: F=0.429, P=.52); journal name (before authorship limitation policy enforcement: F=0.417; P=.97; during authorship limitation policy enforcement: F=0.543; P=.77); or presence of authorship limitation policies (F=1.097; P=.30). In contrast, when specialty medicine journals were excluded from the group of general medical journals enforcing authorship guidelines, significant differences were observed when compared with the group not enforcing authorship guidelines. Specifically, authorship rates were significantly lower among general medical journals before enforcement when compared with the group not enforcing authorship guidelines (F=21.2; P=.002). Authorship rates were not significantly different after enforcement of authorship limitation policies for any of the following article classifications: all articles combined (F= 4.172; P=.05), original research (F=4.478, P=.06), review articles (F=0.418; P=.05), randomized controlled trials (F=0.351; P=.56), and multicenter trials (F=1.397; P=.26).

When journals with authorship limitation policies were examined separately, no significant differences in authorship rate were detected after implementation of these policies compared with before implementation for the entire journal group (matched-pair analysis: F=0.425; P=.79; analysis of variance: F=0.169, P=.68) or for the general medicine subgroup as discussed herein (matched-pair analysis [all articles]: F=0.132; P=.99; analysis of variance [all articles]: F=0.008; P=.93). When authorship limitation policy methods were compared, neither method led to a significantly different authorship rate after enforcement (disclosures: F=0.059; P=.81; numeric restrictions: F=0.268; P=.61). No differences were observed in the rate between these 2 methods before vs after enforcement (before: F=0.230; P=.79; after: F=0.232; P=.63). When these journals' articles were sorted by subtype, randomized controlled trials (F=6.824; P=.02) had significantly higher postenforcement authorship rates, whereas original research articles (F=2.008; P=.18), review articles (F=0.4338; P=.52), and multicenter trials (F=0.522; P=.48) did not. Paradoxically, these results suggest that authorship rates seemed to increase in some cases, even if not to a significant extent, after implementation of authorship limitation policies (Figure 2).

DISCUSSION

The current study demonstrates that, irrespective of implementation of author contribution attestation requirements or author limits per article, the number of authors per article continues to increase over time. This observation appears to be valid for all journal classifications and article types. On the basis of the Sen's slope estimates of all articles, mean authorship rates have increased by approximately 1.5 authors per article over the 20-year interval. Authorship for multicenter trials and randomized controlled trials seems to be increasing at a significantly higher rate than for other article

TABLE 3. **Authorship Trends From 1986 to 2006 Among Journals With Authorship Limitation Policies**

	All published articles		Original research		Reviews		Randomized controlled trials		Multicenter trials	
Journal	Q (95% CI)	*P* value	Q (95% CI)	*P* value	Q (95% CI)	*P* value	Q (95% CI)	*P* value	Q (95% CI)	*P* value
The Lancet										
Before	0.018 (−0.016 to 0.044)	NS	−0.085 (−0.211 to 0.072)	NS	0.075) (−0.021 to 0.155)	NS	0.086 (−0.001 to 0.135)	NS	0.522 (0.165 to 0.901)	<.01
After	0.017 (−0.007 to 0.041)	NS	0.079 (−0.032 to 0.146)	NS	0.188 (0.151 to 0.289)	<.001	0.525 (0.436 to 0.734)	<.001	0.591 (−0.210 to 1.350)	NS
AIM										
Before	−0.015 (−0.040 to 0.001)	<.05	0.001 (−0.031 to 0.023)	NS	0.013 (−0.117 to 0.163)	NS	0.258 (0.000 to 0.622)	<.05	0.156 (0.004 to 0.363)	<.05
After	−0.022 (−0.067 to 0.029)	NS	−0.035 (−0.145 to 0.062)	NS	0.087 (0.019 to 0.156)	<.05	0.216 (−0.018 to 0.449)	NS	0.266 (−0.190 to 0.620)	<.05
BMJ										
Before	0.002 (−0.023 to 0.022)	NS	0.062 (0.035 to 0.092)	<.01	0.043 (−0.025 to 0.117)	NS	0.120 (0.000 to 0.511)	<.05	0.414 (0.098 to 0.750)	<.05
After	0.045 (−0.015 to 0.118)	NS	0.128 (−0.082 to 0.411)	NS	0.142 (0.084 to 0.200)	<.01	0.280 (0.131 to 0.518)	<.01	0.056 (−0.462 to 0.394)	NS
JAMA										
Before	−0.021 (−0.027 to 0.115)	NS	−0.105 (−0.282 to 0.036)	NS	0.237 (−0.177 to 0.784)	NS	0.209 (0.122 to 0.351)	NS	0.313 (−0.248 to 0.755)	NS
After (2000-2006)	0.021 (0.026 to 0.395)	<.05	0.424 (0.027 to 0.479)	NS	−0.243 (NA)	NA	0.434 (0.157 to 0.648)	<.05	0.223 (−0.365 to 0.481)	NS
After (1986-1997)	0.038 (0.003 to 0.072)	<.05	0.017 (−0.035 to 0.080)	NS	0.113 (0.050 to 0.219)	<.001	0.275 (−0.071 to 0.712)	NS	0.438 (0.154 to 0.763)	<.05
NEJM										
Before	−0.004 (−0.068 to 0.152)	NS	0.084 (−0.024 to 0.327)	NS	−0.068 (−0.118 to 0.043)	NS	−0.017 (−0.119 to 0.604)	NS	0.531 (−0.156 to 0.746)	NS
After	0.056 (0.033 to 0.078)	<.001	−0.020 (−0.069 to 0.026)	NS	−0.005 (−0.014 to 0.017)	NS	0.524 (0.405 to 0.727)	<.001	0.563 (0.371 to 0.740)	<.001
AGP										
Before	0.130 (0.044 to 0.219)	<.01	0.103 (0.001 to 0.416)	<.05	0.037 (−0.110 to 0.159)	NS	0.105 (0.069 to 0.263)	<.05	1.15 (−0.938 to 0.826)	<.05
After	0.170 (0.080 to 0.307)	<.01	0.132 (0.004 to 0.304)	<.01	0.162 (−0.078 to 0.938)	NS	0.191 (0.015 to 0.350)	<.001	0.093 (−0.646 to 1.006)	NS
AJR										
Before	0.065 (0.035 to 0.112)	<.001	0.061 (0.030 to 0.097)	<.01	0.118 (0.090 to 0.138)	<.001	0.348 (0.001 to 0.667)	<.05	0.072 (−0.149 to 0.467)	NS
After	0.213 (NA)	NS	0.222 (NA)	NS	0.164 (NA)	NS	0.436 (NA)	NS	0.138 (NA)	NS
Radiology										
Before	0.090 (0.032 to 0.123)	<.01	0.089 (0.043 to 0.133)	<.01	0.018 (−0.053 to 0.090)	NS	0.167 (−0.172 to 0.613)	NS	0.100 (−0.279 to 0.684)	NS
After	0.134 (0.035 to 0.222)	<.05	0.155 (0.074 to 0.212)	<.05	0.110 (−0.056 to 0.348)	NS	0.185 (−0.065 to 0.398)	NS	0.116 (−0.337 to 0.701)	NS

Sen's slope coefficient (Q, authors per article per year) with 95% confidence intervals (CIs) and statistical significance of slope calculations (*P* value) are shown for each journal and article subtype. These slope analysis data are shown for periods before and after enforcement of authorship limitation policies. For each journal and/or time range, trend analysis in number of authors per article is shown as *P* values. *AGP* = *Archives of General Psychiatry*; *AIM* = *Annals of Internal Medicine*; *AJR* = *American Journal of Roentgenology*; *JAMA* = *Journal of the American Medical Association*; *NEJM* = *The New England Journal of Medicine*; NA = not available; NS = nonsignificant.

types, representing an increase in the average number of authors by as many as 10 authors per article during the 20-year period. Our results show that implementation of authorship limitation policies has not slowed the trend of increasing authorship and has, in some limited cases, paradoxically been associated with an accelerated rate of authorship.

Although global statistical analysis does not suggest that implementation of authorship limitation policies had any effect on undeserving authorship, some findings merit comment. First, the data reveal cases of both transient decreases in authorship after authorship limitation policy enforcement (eg, *BMJ*) and increases in authorship rates after enforcement (eg, *The New England Journal of Medicine*, *The Lancet*) that, although clearly present, do not manifest as statistically significant trends. The causes of the transient decrease in authorship rate are unclear but may be

TABLE 4. **Mean Sen's Slope Across All Journals**

	All articles	Original research	Review articles	Randomized controlled trials	Multicenter trials
Before enforcement	0.078±0.049	0.112±0.065	0.122±0.260	0.209±0.556	0.508±0.610
After enforcement	0.081±0.084	0.109±0.146	0.069±0.138	0.111±0.139	0.293±0.212

Sen's slope ± 1 SD (mean number of authors per article per year) is shown for all articles and article subtypes before and after enforcement of authorship limitation policies.

attributable to changes in enforcement of journal policy or adjustment of authorship behaviors after changes in journal rules. The causes of transient increases in authorship rates are less clear, but the long-term increase in authorship may be a function of the increasing complexity of scientific endeavors that leads to an increase in collaborations, and thus authorship, among scientists and academic physicians.[27] This hypothesis is supported by the fact that studies that are intrinsically collaborative in nature (eg, multicenter trials and randomized controlled trials) have the highest authorship rates. In addition, the findings from Bhopal et al[38] suggest that part of the observed trend toward increasing authorship may be a result of dissent against ICMJE guidelines, whereby authors ignore 1 or more of the ICMJE policies. Second, it is apparent that the authorship rate among general medical journals is lower than what is observed in specialty journals. Whether this data trend represents stricter enforcement of policies within general medical journals vs more complex and collaborative studies published within specialty journals remains unclear.

These findings expand on the recent findings of Baerlocher et al,[15] who studied the effectiveness of contribution disclosures among 5 prestigious medical journals during a 6- to 9-year period. Compared with hand searching, our study relied on a quantitative computerized search script to extract and calculate authorship data from online resources, and this approach enabled us to collect a more complete data set that spanned a longer period. In addition, our study benefited from the use of a more robust statistical method to analyze trends over time. Our analysis method also enabled us to independently evaluate the authorship trends among differing article types. Our results cannot directly address the origin of increasing authorship but suggest that the current methods used to discourage unwarranted authorship are either ineffective or, conversely, not addressing the root cause(s) of increasing authorship.

This study had several limitations. First, the study had a nonexhaustive data set, which limits the generalizability of the findings. Although an exhaustive search of the entire PubMed database was considered, it was not thought to be feasible because of logistical issues surrounding manipulation of a data set the size of the entire PubMed database. Second, because of the reliance on PubMed electronic data to generate a data set of sufficient size, indexing errors at the National Library of Medicine, including imperfect classification of publication type and/or number of authors, would be difficult to correct. Third, the study was unable to quantify the compliance with or the efficacy or enforcement of authorship limitation policies and how these factors may function to alter the ratio of true-positive results (ie, undeserving authors were absent, suggesting success of the exclusion mechanism) from false-positive results (ie, undeserving authors were present, suggesting failure of the exclusion mechanism).

CONCLUSION

Undeserving authorship will remain a concern of journals and academicians who work to ensure fidelity in attribution of ideas and work to the appropriate individuals. Our analysis suggests that the long-term trend in increasing authorship has not been affected by formal efforts to prohibit undeserving authorship. These findings should reduce concerns that the observed trend of increasing authorship is a result of undeserving authorship and instead suggest that we should reexamine the causes of these long-term trends.

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